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## HIGH TERRACES AND ABANDONED VALLEYS IN WESTERN PENNSYLVANIA<sup>1</sup>

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EUGENE WESLEY SHAW  
U.S. Geological Survey, Washington, D.C.

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The terraces with which this paper has to do are the well-known gravel-covered rock shelves found along the Allegheny, Monongahela, and other large streams of western Pennsylvania, about 200 feet above present stream channels. The abandoned parts of valleys are closely associated with the terraces, being found at the same elevation, and in many places the two are connected. Fig. 1 shows the principal areas of high terrace. The region includes all the Ohio River basin above New Martinsville, where there was formerly a divide. There are, however, terraces and abandoned parts of valleys of the same age on the Kanawha, Guyandot, Big Sandy, Kentucky, and other streams.

The impressiveness of these features is attested by the long list of names of eminent men who have studied and described parts of them. This list includes Stevenson, Leslie, Jilson, Chance, Wright, Chamberlin, Gilbert, I. C. White, Tight, Campbell, E. H. Williams, Leverett, and others.

Some of the earliest workers believed that the terraces were due to a submergence and marine erosion. Stevenson in 1879 (*Proc. Am. Phil. Soc.*, XVIII, 289-316) called attention to benches along the valley of the Monongahela and its tributaries. He divided them into a higher series of twenty benches, and a lower one of five. The higher series he attributed to marine action. They are probably entirely above those under discussion, and later work on them has shown that they are obscure and are probably due to hard layers of rock. The lower series of Stevenson seems to include those under discussion, and he refers them to stream action, without going into details of development.

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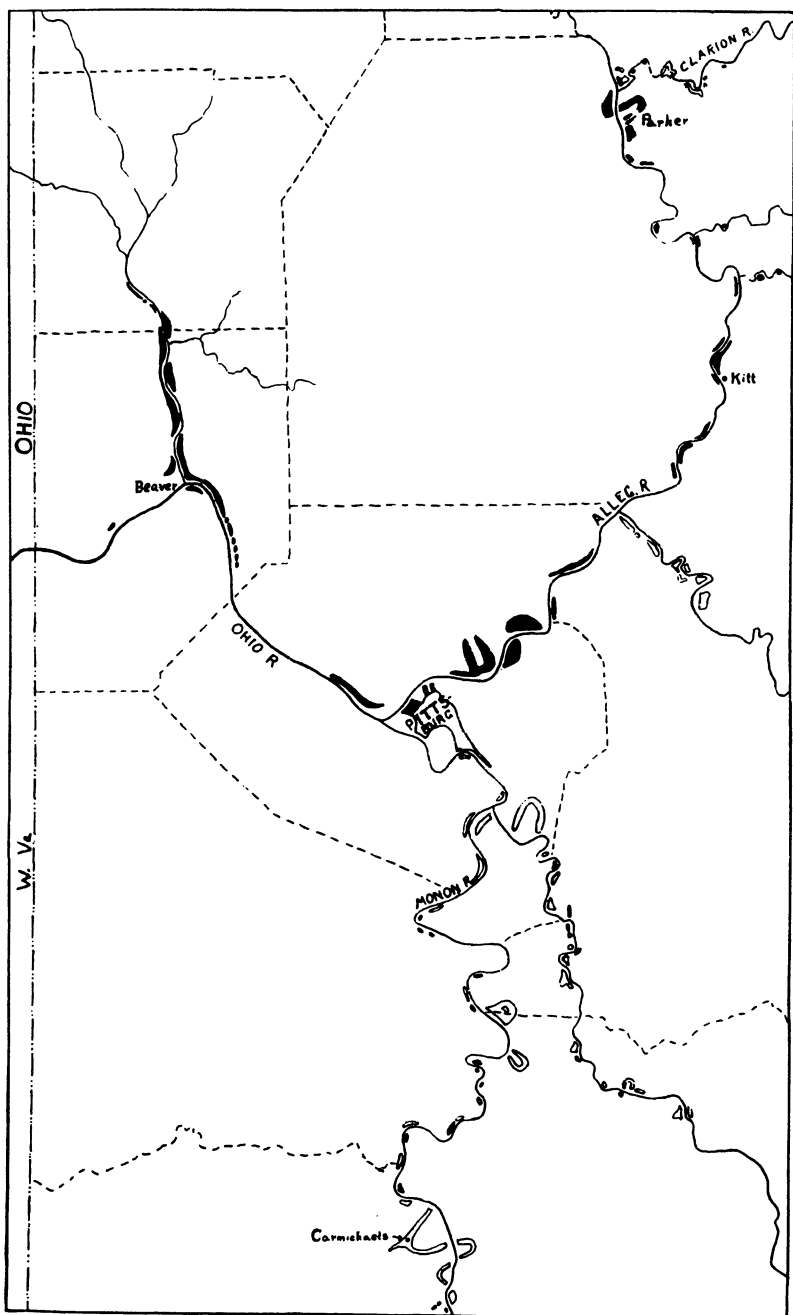


FIG. 1.—Principal areas of high terrace. Black areas have glacial gravel; those in outline have local gravel only.

In 1883 Professor G. F. Wright presented evidence of a large ice dam at Cincinnati, and shortly thereafter Professor I. C. White, in a paper before the American Association for the Advancement of Science, referred the terrace deposits of the Monongahela to that dam.

Chamberlin, in 1890 (*Bull. U.S. Geol. Surv. No. 58*, 13-38), showed that the upper series described by Stevenson could not be ascribed to the ice dam, because of their great range in altitude. He also pointed out certain characters of Stevenson's lower series which indicated that they were of fluvial, not lacustrine, origin. These characters were: (1) the terraces slope with the present streams; (2) the material capping the terraces is distinctly fluvial; (3) they are rock platforms; (4) the form and distribution of the terraces is of fluvial, not lacustrine, order; (5) the abandoned channels must have been of stream origin.

In 1896 Professor White expressed himself (*Am. Geol.*, XVIII, December, 1896, 368-79) as still convinced that the glacial lake, Monongahela, did exist and was responsible for the terrace deposits, but that the ice dam was probably not at Cincinnati, but in the vicinity of Beaver, Pa.

In the Masontown-Uniontown folio, published in 1902, M. R. Campbell advances the theory that the deposits and abandoned channels are due to local ice dams which formed in Kansan time. He points out the fact that it is an extremely difficult and slow process for a stream to cut off any of its meander in a rugged region like Pennsylvania, and that it is impossible for a stream to establish a totally new course unless the conditions under which it operates are very different from those which normally affect the development of streams.

Again, as an objection to the view of Professor White, Mr. Campbell states that while it would be possible for a stream to change its course by superimposition if it were first caused to silt up its valley and then permitted to cut down again, he finds that part of the Carmichaels abandoned channel was not so silted up, and he therefore concludes that the change of course was not due to silting up and superimposition, but to local causes. Mr. Campbell's idea is that ice jams formed in glacial time and that these

grew until they formed huge dams 100 or more feet high, and that they persisted until deposits over 100 feet thick accumulated above them. In many cases these dams not only gave rise to terraces but caused the rivers to abandon their old valleys and cut new ones.

In the *Amity folio* Frederick G. Clapp expresses the belief that Professor White's theory—that of ponded waters throughout much of western Pennsylvania—will best account for the phenomena. He states that the upper limit of the stream deposits in all the valleys of southwestern Pennsylvania and parts of adjacent states has a vertical range of but little over 100 feet, but since Mr. Clapp's work was published the gravel has been found to lie at an elevation of over 1,200 feet on Clarion River, making the vertical range more than 200 feet.

The data gathered by the present writer, instead of lending support to any one of these views, seem rather to indicate that the high terraces and abandoned channels on all the rivers developed as a unit, through the overloading of the Allegheny in early glacial time.

The terraces may be divided into two groups, which have certain essential differences. Those of the first group are capped with glacial gravel, and are found along the Allegheny and Ohio. Those of the second bear material of local derivation, and are found on streams tributary to the Allegheny and Ohio. There are other differences which will be brought out later. In this connection it should be stated that there are a few remnants of older gravels, which lie at various elevations above the main high terrace formation, and in some places have been let down by erosion, so that they seem to connect with the much more extensive deposit below, but the older gravels have very slight extent.

#### TERRACES OF THE ALLEGHENY AND OHIO

The terraces of the Allegheny and Ohio are almost continuous from the mouth of the Clarion to Pittsburgh, and on down the Ohio. The gravel deposits on them are thin or absent where crossed by lateral streams; in other words, where erosion has been most severe; but enough remains to indicate clearly the position of the

original upper surface. At over one hundred places the upper limit of gravel has been determined by level, and that limit is in all cases very nearly 300 feet above present low water. The elevation of the rock floor beneath the deposits has also been determined at many points, and is found to be a little less than 200 feet above the present position of the rivers. Thus, the upper limit of gravel

TABLE SHOWING ELEVATIONS OF HIGH TERRACES IN WESTERN PENNSYLVANIA

Place	Miles from Beaver	Upper Limit of Gravel	Rock Floor	Present Stream	Upper Limit of Gravel above Present Stream
<i>Foxburg quadrangle</i>					
*One mile north of Callensburg.....	110	1,180	1,160±	970	230
*Turniphole.....	108	1,170	1,120— 1,160	930	240
Mouth of Clarion River....	102	1,150	1,035	846	304
Mouth of Bear Run.....	99	1,145	1,025	840	305
Monterey.....	96	1,140	1,015	832	308
<i>Kittanning quadrangle</i>					
Redbank.....	81	1,100	950	810	290
Ford City.....	58	1,025+	885 and 980	763	262+
<i>New Kensington quadrangle</i>					
Tarentum.....	39	1,000+	975	725	275+
<i>Carnegie quadrangle</i>					
Allegheny.....	22	1,000	896	698.4	300+
<i>Beaver quadrangle</i>					
Beaver.....	0	978	900	672	306
<i>Latrobe quadrangle</i>					
*One mile northeast of Blairsville.....	80+	1,060	....	900	160
<i>Burgettstown quadrangle</i>					
*One and one-half miles northeast of Burgettstown	28+	1,028	1,015	947	81

\*Gravel of local derivation (not glacial).

falls regularly from 1,145 feet at Foxburg to 1,010 feet at Pittsburgh; the rock floor beneath the gravel from 1,015 to about 880 feet, and the river from 845 to 700 feet. Here, then, are three approximately parallel planes, each of which slopes about 140 feet in 80 miles. In other words, the gravel formation holds its thickness of about 125 feet, and slopes in the direction of present stream flow. See table. •

The pebbles are well rounded, and lie in a matrix of sand and

clay, though in some places there is so little fine material that the gravel is dug from pits and used without further washing. In such places beds of gravel are separated by lenses of clay, but on the whole the formation is homogeneous.

That the deposit is of fluvial and not lacustrine origin seems to be shown decisively by the characters to which Chamberlin has called attention: The deposit slopes regularly with the present streams throughout their winding courses. A lake deposit would be horizontal unless affected by crustal deformation, and in that case the slope would not change direction at just the places where the course of the river changes. Second, the material is distinctly fluvial, consisting of irregularly bedded gravel which contains lenticular masses of silt and clay. A lake deposit in a valley might have deltas containing some coarse material, but in no way could coarse glacial *débris*, poured into the end of a narrow lake 100 or more miles long, be evenly distributed so that the resulting formation throughout its length would be homogeneous and of uniform thickness.

There seems to be good evidence also, as Leverett has pointed out, that in pre-Glacial time the Clarion was the headwater portion of the Allegheny, a divide crossing the present course of the latter stream just above the mouth of the former, and that the glacier, by cutting off the outlets of the drainage of the area to the north, forced the water to cut across the divide to the old Lower Allegheny, thus thrusting greatness upon the Allegheny basin.

Through the new cut were discharged great volumes of glacial outwash—too great for the Allegheny to transport—and the coarsest part of the *débris* was spread along the bottom of the valley, forming a typical valley train which had a nearly uniform thickness throughout its length. The bodies of gravel on the high terraces of the Allegheny and Ohio, then, are the remnants of this old valley train.

The overloaded condition of the Allegheny was probably due to several causes, among which the following may be mentioned as being more or less effective: First, an actual increase in load derived from (*a*) material fed more or less directly to the streams by the glacier; (*b*) *débris* from the cutting of new gorges across

old divides; (c) material brought after the ice melted, by tributaries as they cut new valleys. Second, a decrease in velocity and carrying power, produced by (a) the attraction of the ice mass; within a degree of the ice front this may so have changed water level that in a stream flowing away from the ice a gradient of  $1\frac{3}{4}$  feet per mile might have been reduced to  $1\frac{1}{2}$  or  $1\frac{1}{4}$  feet per mile; (b) crustal deformation, due to the weight of the ice; (c) the divides crossed; each of these would check the velocity and cause deposits for a short distance upstream; and ice jams operate in a similar way. Third, a possible but not probable decrease in volume, arising from a change in climate. It is probable that during Kansan time the river had a larger volume than now because it was carrying the run-off from a much larger territory.

#### TERRACES OF TRIBUTARY RIVERS

The second group of high-terrace deposits is found on streams tributary to the Allegheny and Ohio. Those along the Clarion River may be taken as typical and described in detail.<sup>1</sup> At Foxburg the high gravels of the Clarion connect and mingle with those of the Allegheny, both the rock floors and the upper surfaces of the deposits connecting, without interruption (see Fig. 3). The Clarion gravels are much like those of the Allegheny, but differ from them in the following respects: First, the material is of local, not glacial, origin. Second, the thickness decreases upstream. Third, the gravels are as a whole much finer, only the base being as coarse as the glacial gravels. There are some minor points of dissimilarity, but these are the important ones in the present discussion.

In present distribution the gravels are as continuous as those of the Allegheny. There is scarcely a half-mile of the lower part of the valley where they are absent or even approximately so.

That the Clarion terraces are of stream origin is shown by characters similar to and as decisive as those of the Allegheny terraces mentioned above, and certain important features indicate the immediate cause of the accumulation of gravel. First, at the confluence of the two rivers the high-terrace gravels correspond exactly in elevation and thickness. Second, the Clarion gravel rises and

<sup>1</sup> See Foxburg-Clarion folio, *U.S. Geol. Surv.* (in press).

becomes thinner and narrower upstream, and at a distance of 20 miles from the Allegheny the formation has the width, thinness, and coarseness of an ordinary flood-plain deposit.

These facts suggest at once that the Clarion terraces owe their existence to conditions on the river into which that stream discharged. When the Allegheny began to aggrade, the effect was that of a gradually growing dam across the mouth of the Clarion. This caused the latter stream to drop the coarsest part of its load. The dam did not grow so rapidly as to produce a pond in the river above, but aggradation kept pace with the growth of the dam. In other words, at its mouth the Clarion built up as rapidly as the Allegheny. This is shown by the even downstream dip of the Clarion gravels and by their coarseness. If any ponded stage had existed, the deposit would have been coarse only at the upper end of the pond and would have taken the form of a delta.

But of course the dam did not affect the Clarion throughout its length. On the contrary, when the dam began to grow, its influence was felt only in that part of the stream immediately above. As it grew the area affected by it extended farther and farther from the Allegheny and the river built up to a new gradient, over which it was just able to carry its normal load. The coarser part of the gravel was dropped where the gradient changed from the old to the new. This point gradually moved upstream and the extended coarse deposit became the basal coarse part of the formation. The Clarion then silted up because its master stream, the Allegheny, was aggrading, and the elevation of its outlet was being raised. The Allegheny aggraded because of great increase in load, the Clarion because of decrease of gradient. The absolute load of the latter stream has not changed materially since the dawn of the Quaternary period.

Space will not permit of complete description of all the high terraces, but the work of the Clarion may be taken as a type of the work of those streams which discharged into the overlaid Allegheny and Ohio. Redbank Creek, the Conemaugh, Kiskiminitas, Youghiogheny, and Monongahela show similar characters. On all except the smallest of the tributaries of the Allegheny, there are deposits connecting with the early glacial valley train, such

deposits rising, thinning, and narrowing upstream, and consisting of mixed coarse and fine material of local origin, the proportion of fine being somewhat greater than in the valley train. The larger the tributary the more gradually does the deposit rise and thin, for the larger streams have less fall, and there is less difference between the old gradient, with which the streams were more than able to carry their loads, and the adjusted gradients, with which the streams did neither cut nor fill.

To illustrate, certain facts indicate that in pre-Glacial time the lower 50 miles of the Monongahela had a fall of about one foot

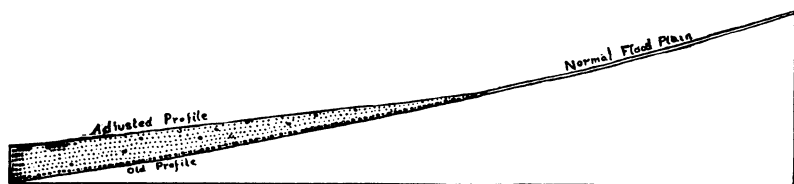


FIG. 2.—Longitudinal section of deposit on a stream tributary to one which is overloaded with glacial débris. A distinguishing character of such deposits is that they are definitely limited upstream by the convergence of the old profile in use when the stream was cutting down, and the adjusted profile with which the stream is just able to carry the load delivered to it by headwaters and side streams.

per mile, that the adjusted gradient was about 9 inches per mile, and that the valley train athwart the mouth of the river was about 110 feet thick. At this point the Monongahela fill should have been 110 feet thick, and this thickness should have decreased upstream by 1 foot minus 9 inches, or 3 inches per mile, and at 50 miles the formation should have been thinner by 130 inches, or  $12\frac{1}{2}$  feet. The results obtained by actual observation in the field accord very closely with these figures. The deposit is nearly 100 feet thick at the West Virginia line.

As another example, the Clarion gravels thin almost 50 per cent in 10 miles. Originally, as indicated by the base of the gravels, the stream had a fall of about 125 feet in the lower 10 miles of its course. The adjusting of the gradient reduced this to 60 feet. The difference between these figures, or 65 feet, plus the thickness of the deposit at the upper end of the 10 miles, or 50 feet, is 115 feet, which is the thickness of the deposit at the lower end of the valley.

To sum up, the inferred history of the terraces reads about as follows. The Allegheny was overloaded at a certain point. The material was spread out evenly from the place of overloading. On each tributary stream deposits accumulated, first at the point of junction with the overloaded one, then farther and farther upstream. These processes continued until the load and gradient of the Allegheny were so adjusted that the river was able to carry its load. Later, probably on account of an elevation of the land, the stream has cut through its deposit and 200 feet below the level of the old rock floor.

“ABANDONED CHANNELS”

In close association with the high terraces are the many so-called abandoned channels or side tracks to the main lines of drainage. Examples are found not only in western Pennsylvania, but along the Ohio, Mississippi, and a large number of tributary streams. Genetically these features seem to be similar, though some developed early in the Quaternary period and others later.

The abandoned part of the Monongahela valley at Carmichaels, Pa., referred to on p. 142, has been described as containing evidence of a huge local dam of ice, but to the present writer the evidence did not seem to indicate a local barrier for the following reasons: (1) The deposit thins at the position of the supposed dam not abruptly, but irregularly, and a mile or more below considerable thicknesses are found. (2) Just below the place of thinning, the formation extends up the valley side to the altitude of the upper limit of gravel, and a little farther away are extensive bodies of the deposits, fully 100 feet thick. (3) The thinner parts are found at a place where erosion has been very severe—where the gravel has been dissected by a good-sized tributary. It appears, therefore, that the thin part of the deposit is simply a result of irregular clearing-out of the old valley by the tributary and is a feature to be expected. The stream seems to have cut down quickly through the silt and gravel, but when it came to hard rock it hesitated, meandered a little, and then cut down farther, leaving the shelf covered with pebbles and bowlders concentrated from the original deposit. The fact that just below the site of the dam the formation is found

today extending up on the side of the valley and a few miles away the full thickness of over 100 feet is present, is evidence that the deposit was formerly 100 feet deep here as it is elsewhere. There could scarcely be any other possibility except that the valley-side deposit represents an older fill, and there is no foundation for such an assumption.

A theoretical consideration of the question of local ice dams yields interesting results. The possibility of an initial ice jam is not to be questioned. Moreover, the supposition that such a jam might be large in a northward or iceward flowing stream in a subglacial climate is reasonable and is supported by known conditions on the McKenzie and other streams which work under somewhat similar circumstances.

But the ice dams in this case must have been several times as high as the highest known and must have persisted through many summers warm enough to melt back the thousands of feet of ice in a continental ice sheet. Indeed if we assume that the Monongahela carried the same amount of suspended matter which it carries today (in all probability it did not carry so much), that all its load of undissolved matter was dropped, and that immediately after the reservoir became filled the dam went out, we get a minimum estimate for the life of the dam of about 1,000 years. If only a quarter of the material were dropped the time would be 4,000 years.

During this time the run-off of the basin must have passed over the dam, for if the dam had suddenly risen above the height of cols in near-by divides, the lake immediately behind the dam would not have been silted up. Moreover, considerable coarse material is found just above the supposed dam, indicating that there were strong currents and that only a small fraction of the suspended matter was dropped.

The hypothesis of an ice dam, therefore, involves the assumption that the Monongahela, which since early glacial time has, with a very low gradient, removed rock material to a depth of 200 feet for more than 100 miles, was for centuries unable to cut through or undermine these blocks of ice over which its gradient and eroding power must have been that of a cascade or waterfall. The assumed floor of the valley below the site of the dam is 60 feet below

the top of the fill above the dam. The drop in water level must have been as great or greater, and yet the dam must have withstood the pressure and the wear year after year for thousands of years.

*Parker oxbow.*—One of the most famous of the abandoned valleys is the old oxbow at Parker's Landing (see Fig. 3). It was first described in detail by Chance (*Second Geol. Surv. of Pa.*, Rept. VV, 1880, 17-22). He calls attention to the disproportionate size and breadth of the valleys of the two small streams which now flow from the oxbow, and also to the fact that between the heads of the streams there is low swampy ground. Glacial gravels of probable Kansan age are found almost continuously around the loop and in some places the deposit is over 50 feet thick. Chance inferred that at the time of the earliest ice advance this oxbow was occupied by the Allegheny River, and at a subsequent time the neck was severed.

G. F. Wright held that this channel was formed and abandoned before glaciation, and that the glacial material now found in the oxbow was deposited there at a time when the Allegheny, being overloaded with Kansan outwash, aggraded up to a position somewhat above the oxbow; that the gravel was carried into the ends of the loop, but the river never reoccupied the entire loop. Wright has long advocated the idea that the Allegheny was cut to about 50 feet below its present channel in pre-Glacial time, and that the glacial valley train was thus about 350 feet thick, filling the inner gorge and part of the broad valley above.

Chamberlin and Gilbert studied the problem in 1889, and their conclusions agree essentially with those of Chance, and are found in *Bulletin U.S. Geological Survey No. 58*, 31.

In 1894 Wright again published a paper (*Am. Jour. Sci.*, 3d ser., XLVII, 173-75) in which he holds to his previous conclusions.

In 1900 E. H. Williams presented a paper at the Albany meeting of the Geological Society of America (*Bull. G.S.A.*, XII, 1900, 463) in which he agreed with Wright that the river has not occupied the oxbow since the beginning of the Glacial period, but he went so far as to hold that the river never did flow around the so-called oxbow. He ascribes the feature to the work of two small streams which "rise on opposite sides of a low col and de-



FIG. 3.—Topography of “Parker oxbow” and vicinity. (Shaded part shows area occupied by high-terrace gravel.) (From Foxburg, Pa., topog. sheet, *U.S. Geol. Survey*.)

bouche into the Allegheny gorge within a mile of one another, and in Glacial time these two valleys were filled by overwash deposits mingled with material from the immediately adjacent slopes." He states also that the rock floor of the abandoned channel is not level, but falls down rapidly toward the river. He does not, however, explain the fact that the col between the heads of the two streams is low and swampy, whereas there is not a case of two large streams rising in an area of swampy ground in the whole unglaciated area of western Pennsylvania, and he says nothing about the broad steep-walled valley through which the small streams flow.

Frank Leverett (*U.S. Geol. Surv. Mon. 41*, 242) considers E. H. Williams' view "more consistent with the features than the one presented by Chance," and says further (apparently misinterpreting Williams' view): "It refers the opening of the double channel, resembling the forks of an oxbow, to a shifting of a smaller tributary of the Allegheny from one side to the other of a low hill that stood nearly opposite the point at which the tributary entered the valley."

The data gathered by the writer indicate, first, that the so-called Parker oxbow is an abandoned channel of Allegheny River, and so is properly called an oxbow. The characters which force such a conclusion are: (a) the depression has the size and shape of the Allegheny valley, having a comparatively uniform width of about a mile, and bounding walls from 100 to 300 feet high; (b) the shape is a broad smooth curve with the side of the valley inside the loop gently sloping, and that outside high and steep like the present valley around curves of the river (it resembles, for example, the curve of the Clarion 1 mile south of Turniphole, Foxburg quadrangle); (c) a current with something like the strength of a river must have flowed around the bend, for pebbles up to 6 inches in diameter are found at the most extreme part of the loop.

Second: The abandoned channel was occupied in a part of Kansan time. The presence of Kansan outwash on the floor, which is at nearly the same elevation as the floor under Kansan material near by, indicates that the last great event before the abandonment of the oxbow was the advance of the Kansan ice

sheet. The abandonment took place before the stream began again to cut down, for deposits are found around the loop almost as high as the highest gravel. The broad valley around the oxbow was cut previous to this time. One can only conjecture how long a period of time was necessary for this.

There is some evidence that the rock floor of the east end of the loop is higher than the Parker strath. If this be true the oxbow must have been developed either in pre-Kansan time, before the stream had cut as low as the Parker strath, or after the Allegheny had aggraded until it was high enough to take this route.\* However this may be, the close association of the abandoned channel with the high terrace, and the occurrence of Kansan material in the channel, show that whenever it was formed, it was occupied and abandoned in Kansan time.

Third: The length, depth, and narrowness of the rock channel through which the river now flows across the neck of the oxbow suggests that the oxbow was not cut off in the way that streams ordinarily cut off their meander, but points rather to superimposition. The present valley across the neck of the abandoned channel is a narrow rock gorge over a mile long, and the top of the gorge extends up to the level of the highest part of the old channel.

Another abandoned valley which is thought to show the method of development very well is found on the Allegheny, a few miles northeast of Pittsburgh, and opposite Verona. The topography suggests at once that this feature is a cut-off loop of the Allegheny, and it is found on a level with the high terraces. The width is nearly as great as that of the old valley of the Allegheny, and glacial gravels are found in it. But on closer inspection it is found that the width of the valley and the thickness of the deposit decrease rapidly away from the present course of the river, and this through a rise in the rock floor. Also there is an impressive amount of fine material and a scarcity of bowlders. Finally, at the extreme end of the loop the old valley, if such it be, is very narrow, and the deposit but a few feet thick.

The meaning of these features seems quite evident. At the time the Allegheny began to aggrade, the position of this loop was occupied by two small tributary streams. The divide between them

was, at one place, a little less than 100 feet above the river-valley floor. As the river rose it dropped some coarse materials in the ends of the tributary valleys, but a mile away the ponded water was quiet and the deposit fine. This process continued until the Allegheny reached the elevation of the lowest point in the divide between the streams, about 3 miles away. Then the river current was separated and a part flowed slowly up one tributary and down the other, carrying some coarse and much fine material (varying from season to season) and shaping the col into the form of a valley. Finally the river cut down again, abandoning the course which it had occupied temporarily for the much shorter original course.

A part of the history of the loop is reflected also in its present drainage. When the river left it, the run-off was naturally in the direction in which the river had flowed, out one arm and back down the other. But a new small tributary in the position of the upper one of the old ones is now cutting back into the upper end of the abandoned valley, driving the head of the other stream back and annexing a part of its unnatural drainage basin.

All of the other abandoned parts of the valleys of this region have been examined carefully and seem to have been developed in the same way—by silting up and redissection—and the process is the same whether the case be on the Allegheny or on one of the tributary streams. In many cases the new courses made available by the silting-up of the old channels were about as direct as the old, and in certain of such cases the stream cut down in its old course, while in others it assumed a new course. Thus some of the abandoned valleys mark courses temporarily occupied by the rivers, while others show old and long-used courses. It is a significant fact that the changes were, in nearly every case, from a longer route to a shorter one. This would scarcely have been true had the rivers been driven from their courses by ice dams. There are some cols which stand just a few feet higher than the highest gravel, and these were, of course, never crossed by the rivers. Indeed, if aggradation had proceeded 50 or 100 per cent farther there would have been an amazing network of long and devious “abandoned” valleys.

## SUMMARY

Summarizing, the method of development of the high terraces and abandoned parts of valleys of western Pennsylvania seems to be as follows: (1) The development of a valley train over 100 feet thick, along the Allegheny and Ohio; (2) from the beginning the aggradation of this stream produced an effect felt on every tributary, and a portion of each, beginning at its mouth and extending gradually upstream, became silted up. (The lower end of each tributary valley thus took on a form resembling the half-filled character of the valley of the master stream.) (3) As the rivers built up they found themselves flowing at the height of one after another of the lowest places in near-by divides, and at such times and places the currents were divided and the cols were occupied. This overloaded condition of the streams lasted a long time and there were many fluctuations, for at some places, as at Pittsburgh and Belle Vernon, there are two or three well-developed valleys side by side. (4) When final redissection began, the rivers chose the channels momentarily most desirable. In most cases the short route was the principal factor in the choice, but in others the largest current at the time and other comparatively trivial conditions determined the courses of the streams. As in all cases of superimposition, the resistance of underlying rock played no part in their location, and at many places the rivers soon found themselves sawing into hard rock where near by were courses through unconsolidated materials.